Schofield Barracks, Wheeler Army Airfield & Fort Shafter
Oahu, Hawaii

Crash Location Enhancement Studies

prepared for

Military Traffic Management Command
Transportation Engineering Agency
Corps of Engineers, Norfolk Division

March 2000

prepared by

Gannett Fleming

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EXECUTIVE SUMMARY

SCOPE

The Military Traffic Management Command Transportation Engineering Agency (MTMCTEA), through Gannett Fleming, conducted crash location enhancement studies at Schofield Barracks, Wheeler Army Airfield and Fort Shafter, Hawaii. The studies were conducted from 14-24 February 2000. The main objective of the studies was to investigate and make recommendations to improve traffic operations and safety.

FINDINGS AND RECOMMENDATIONS

This report analyzed one high accident location at Schofield Barracks: the intersection of Foote Avenue and A Road.

Safety audits were also conducted for each installation's primary and secondary roadways. The focus of the audits was to evaluate traffic control devices and to identify potential roadside safety hazards. The study areas for each installation are shown in figures 1-3.

LOCATION	FINDINGS	RECOMMENDATIONS AND COST
Schofield Barracks		
Foote Avenue and 'A' Road	• Significant delay exists during the mid-day and evening peak hours. • The 3-year crash history includes 32 crashes. • Southbound A Road traffic, looking eastward, has limited sight distance due to the location of an installation destination sign.	• Install an actuated traffic signal, with pedestrian activation. The estimated cost of this improvement is $70,000. • Relocate the destination sign posted on the northeast quadrant of the intersection. The estimated cost of this improvement is $250.
Safety Audits	• Numerous fixed objects were found to lie within the required clear zone. • Many drainage features on post are serious safety hazards because they present obstacles that may be impacted by motorists. • Most pavement markings throughout the post are worn and faded. • Sidewalks along Trimble Road are unprotected from traffic. • There is a general lack of lane-use signing. Also, multiple signs were found mounted to a single post. • Access control was not present at some parking areas.	**ASSOCIATED TYPICAL COSTS** • Light Pole/Utility Pole Relocation - $5,000 - $10,000 EA • Concrete Curb - $30 per LF • Inlet - $3,500 to $4,500 EA • Concrete Headwall with Wingwalls - $2,500 EA • 30" Diameter RCP - $85 per LF • 30" Diameter CGSP - $45 per LF • Guardrail - $30 per LF • Concrete Curb - $30 per LF • Pavement Markings - $0.50 to $3.00 per LF • Signing - $30 per SF

<table>
<tr><td>Operational Evaluations</td><td colspan="2">• Macomb-Kolekole Connector will improve east-west traffic flow. More direct north-south access is needed.
• Conversion of Foote and Waianae Avenue to two-way operation is suggested. A more detailed study is first required.
• Based on available data, a traffic signal is warranted at the intersection of Trimble Road/Foote and Heard Avenues. Operational improvements are also suggested based on future operation of Foote and Waianae Avenues.</td></tr>
<tr><td colspan="3">Wheeler Army Airfield</td></tr>
<tr><td>Safety Audits</td><td>• A rock wall on Wright Avenue is unprotected from traffic.
• Most pavement markings throughout the post are worn and faded.
• Crosswalks are not properly signed and marked.
• ONE WAY and STOP signs are missing along Wright Avenue.
• Some faded signs were noted.
• Numerous signs are incorrectly mounted.</td><td><u>ASSOCIATED TYPICAL COSTS</u>
• Concrete Barrier Tapered End Section - $500 EA
• Crash Attenuator - $2000 EA
• Signing - $30 per SF
• Pavement Markings - $0.50 to $3.00 per LF</td></tr>
<tr><td>Operational Evaluations</td><td colspan="2">• The median on Santos Dumont Avenue in the area of Lauhala and Warhawk Field Roads should be widened to improve intersection operations.
• Left turns from Lauhala Road Gate onto Kamehameha Highway should be prohibited through signing or geometric improvements.</td></tr>
<tr><td colspan="3">Fort Shafter</td></tr>
<tr><td>Safety Audits</td><td>• Roadside parapets are a hazard.
• Roadside hazards are missing object marker signs.
• The use of pavement markings is inconsistent.
• Some speed limits are unrealistically low.
• Multiple signs were found mounted to a single post.</td><td><u>ASSOCIATED TYPICAL COSTS</u>
• Concrete Barrier Tapered End Section - $500 EA
• Signing - $30 per SF
• Pavement Markings - $0.50 to $3.00 per LF</td></tr>
<tr><td>Operational Evaluations</td><td colspan="2">• Existing signing and marking deficiencies should be corrected at the C and G Street intersection with Funston Road.
• Review of plans for the relocation of the C Street approach to Funston Road indicate signing and marking inconsistencies.
• At the Bonney Loop intersection with Funston Road, ADA requirements should be met and truck/bus restrictions posted.
• The Wisser and Macomb Road intersection with Pierce Street as well as the Funston and Wisser Road intersection with Carter Drive should both be converted into typical four-legged intersections. The current configurations result in more conflict points than necessary.</td></tr>
</table>

FURTHER ASSISTANCE

Findings and recommendations in this report are based on analyses of data obtained during the field survey, review of crash reports provided by the Directorate of Public Works (DPW) and through conversations with installation personnel. Questions regarding the recommendations in this report should be referred to MTMCTEA.

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FINDINGS AND RECOMMENDATIONS

METHODOLOGY

This report analyzed one high accident location at Schofield Barracks: the intersection of Foote Avenue and A Road.

Safety audits were also conducted for each installation's primary and secondary roadways. The focus of the audits was to evaluate traffic control devices and to identify potential roadside safety hazards. The study areas for each installation are shown in figures 1-3.

When operational improvements are implemented, safety is improved as well. Therefore, several areas of operational concern were evaluated to determine if traffic operations could be improved. A total of four corridors and seven intersections were included in this operational evaluation.

The study team performed the following tasks to identify and resolve traffic and safety concerns at the study locations:

1. ***Data Collection*** – Morning, mid-day, and evening peak-hour turning movement counts were conducted at the intersection of Foote Avenue and A Road. Crash location information was provided by the DPW. Safety audits were conducted on all primary and secondary installation roadways. Additionally, photographs were taken.

2. ***Field Investigations*** – Several field observations were conducted to assess traffic flow and safety operations at study intersections. Traffic operations were monitored during critical time periods to help identify safety deficiencies.

3. ***Analysis and Problem Identification*** – Data was analyzed using traffic engineering and safety standards from the following sources:

   - *Highway Capacity Manual* (HCM), Transportation Research Board Special Report 209, 1994 and 1997
   - Highway Capacity Software (HCS), developed by FHWA and distributed by McTrans
   - *Manual on Uniform Traffic Control Devices (MUTCD),* FHWA, 1988
   - *A Policy on Geometric Design of Highways and Streets*, American Association of State Highway and Transportation Officials (AASHTO), 1994
   - *Roadside Design Guide*, American Association of State Highway and Transportation Officials (AASHTO), 1996
   - *Traffic Engineering Handbook*, 4th Edition, ITE, 1992
   - *Traffic Planning Handbook*, ITE, 1992
   - *MTMCTEA Pamphlet 55-10, Traffic Engineering for Better Roads,* 1985
   - *MTMCTEA Pamphlet 55-14, Traffic Engineering for Better Signs and Markings,* 1985
   - *MTMCTEA Pamphlet 55-17, Better Military Traffic Engineering,* 1987
     Location Maps Here, Pages 8-10

FIGURE 1
SCHOFIELD BARRACKS
SITE MAP

Gannett Fleming

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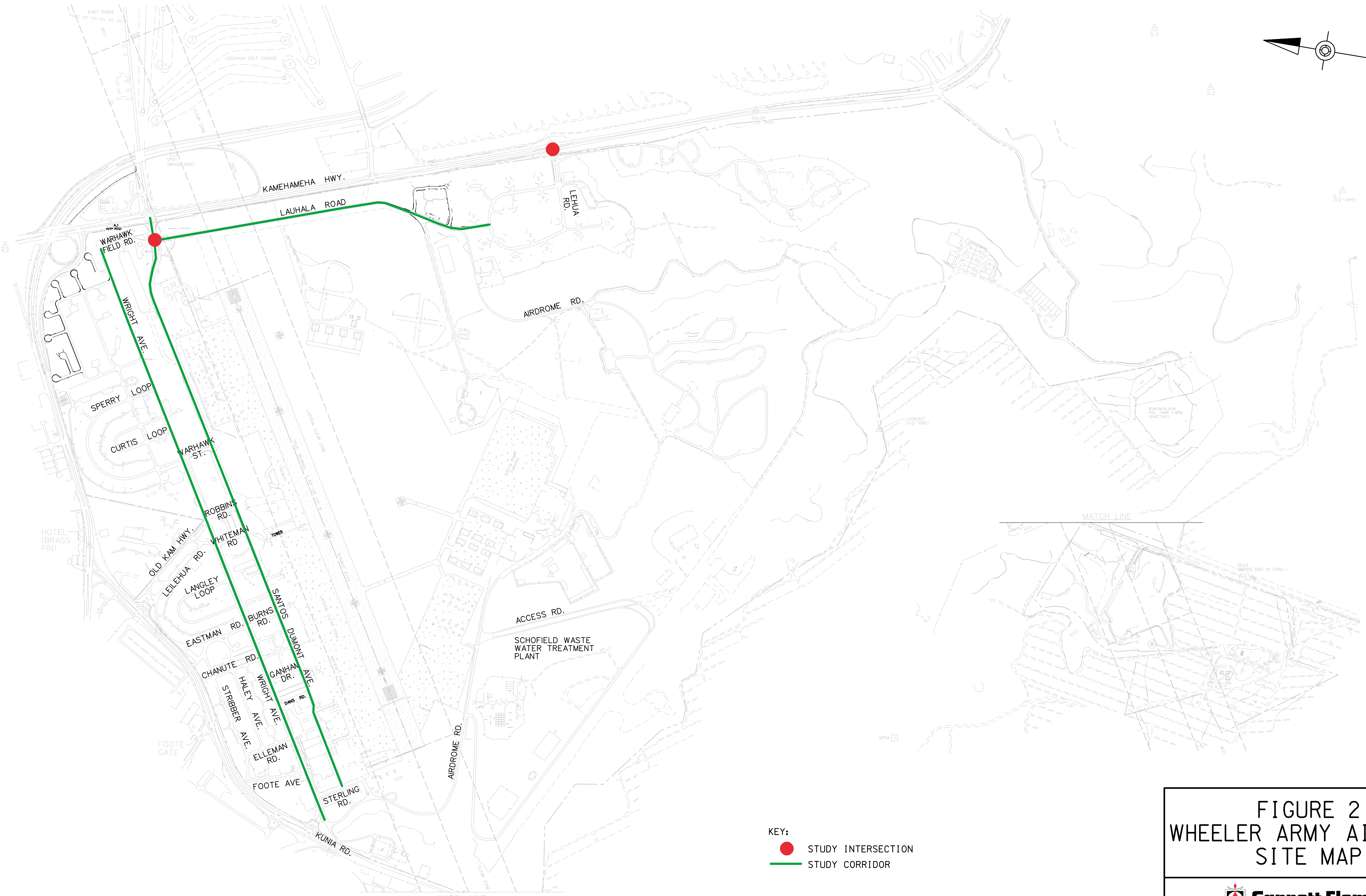

FIGURE 2
WHEELER ARMY AIRFIELD
SITE MAP

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FIGURE 3
FORT SHAFTER
SITE MAP

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Traffic volumes and lane configurations were used in HCS to determine intersection levels of service (LOS). LOS describes the operational condition of an intersection and usually falls into one of six categories, A through F. LOS A represents the best operating conditions and LOS F represents the worst condition. LOS E is the value that corresponds to the capacity of a facility where delays become intolerable and queues begin to form. Generally, a facility operating at or better than LOS D is considered acceptable. Appendix A details and graphically shows examples and definitions of LOS A through F. Appendix B provides peak-hour LOS summaries for the intersection of Foote Avenue and A Road.

4. ***Recommendations*** - From the accident reports, traffic volumes, LOS, and field observations, recommendations were developed for each location studied.

   It should be noted that MTMCTEA publicizes highway safety because of the many deaths and injuries that occur on military installations each year. Highway accidents and their severity are caused by one or more of the highway system elements: the roadway, the vehicle, and/or the driver. Many times, law enforcement officials tend to blame accidents directly on the driver. Even if the driver was at fault, did the road or roadside environment contribute to the severity of injuries or property damage costs? Too often the driver takes the blame, while other causative factors remain hidden. The driver is expected to compensate for inadequate highway design and control measures in his/her driving tasks. Transportation engineers know a definite correlation exists between accidents or accident severity and substandard design or inadequate control measures. Accident causes and their destruction intensity must be clearly defined and related to the highway system elements.

   Often fatal and serious injury accidents occur because motorists impact highway hazards. Even though the accident cause is listed as driver error such as running off the road, speeding, driving under the influence (medicinal drugs), driving while intoxicated, falling asleep, etc., there are contributory factors surrounding an accident that affect the severity. In other words, the highway features are not forgiving or crashworthy. In the case of traffic control devices, they may be unnecessary, non-standard, or confusing.

PROGRAMMED IMPROVEMENTS

According to officials at the Hawaii Department of Transportation (DOT) Planning Organization, the long-range plan (2020) includes the widening of Kunia Road to 6 lanes between H1 and the Royal Kunia housing development. This development is located along Kunia Road about 8 miles south of Schofield Barracks and Wheeler AAF. The remainder of Kunia Road is programmed to be widened to 4 lanes; however, it is likely that this project will not be funded before 2020.

Another project involves the installation of a traffic signal at the intersection of Kunia Road with the Kunia Regional SIGNIT Operations Center access road, located just south of the installation. The traffic signal is programmed to be installed in July 2000. Installation of this signal will not affect traffic operations along Kunia Road in the vicinity of the study installations.

No road improvements are programmed along Kamehameha Highway, in the vicinity of the Wheeler AAF housing gate. Hawaii DOT officials have been made aware of the dangerous left-turn movement from Lehua Road onto Kamehameha Highway. MTMCTEA will provide a copy of the final report to Hawaii DOT officials

HIGH ACCIDENT LOCATIONS

SCHOFIELD BARRACKS

Intersection of Foote Avenue And A Road

Existing Conditions:

- ***Control:*** STOP control on A Road approaches
- ***Speed Limit:*** 25 mph on all approaches
- ***Roadside Hazards:*** None
- ***Sight-distance Restrictions:*** Southbound traffic, looking eastward (towards Foote Avenue Gate), has limited sight distance
- ***Street Lighting:*** Northeast and southwest quadrants
- ***Morning Peak Hour Traffic:*** Total intersection volume of 873 vehicles (refer to fig 6 for turning movement counts)
- ***Mid-day Peak Hour Traffic:*** Total intersection volume of 1,244 vehicles (refer to fig 6 for turning movement counts)
- ***Evening Peak Hour Traffic:*** Total intersection volume of 1,188 vehicles (refer to fig 6 for turning movement counts)
- ***Pedestrian Level:*** Minimal at time of data collection with exception of PT activities during morning time period
- ***Restrictions:*** None

Figure 4. Intersection of Foote Avenue and A Road (southward view)

Figure 5. Intersection of Foote Avenue and A Road (eastward view)

- ***Crash History***:

  - CY99 - 15 crashes reported (5 - category 1; 8 - category 3; 2 - category 4)
  - CY98 – 7 crashes reported (6 - category 3; 1 - category 4)
  - CY97 – 10 crashes reported (3 - category 1; 7 - category 3)

  Categories are as follows:
  Category 1 – under $1000 damages without injuries
  Category 2 – under $1000 damages with injuries
  Category 3 – over $1000 damages without injuries
  Category 4 – over $1000 damages with injuries
  Category 5 – fatalities

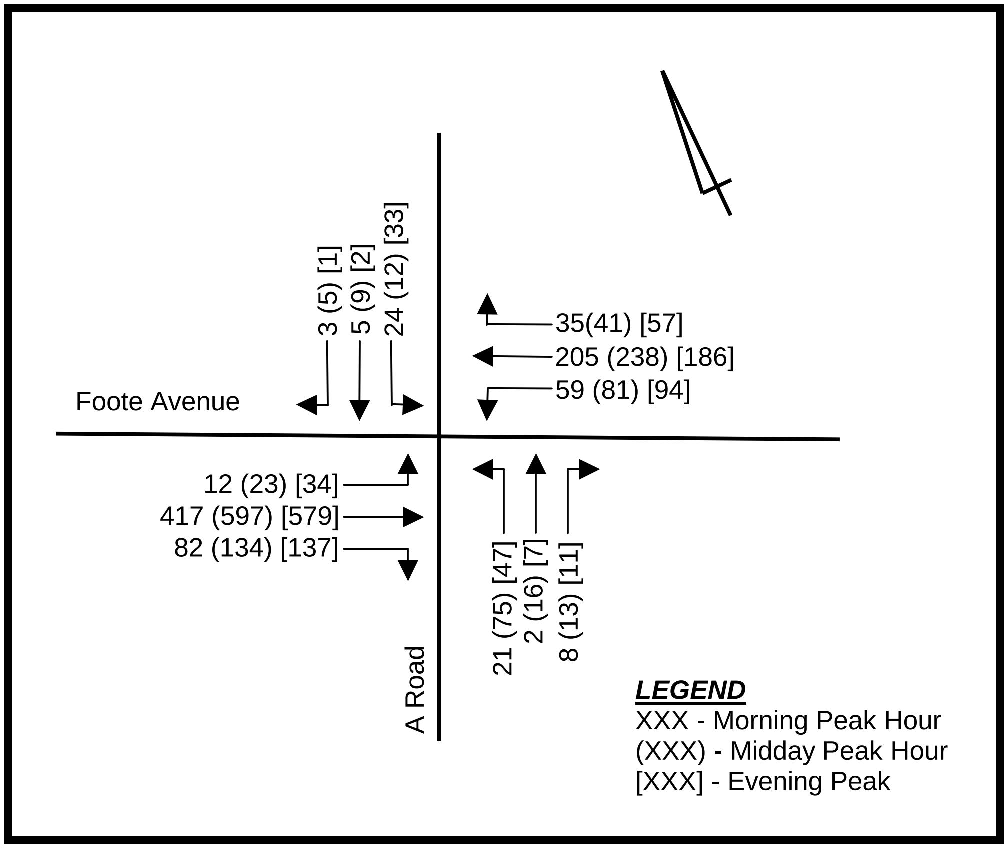

Figure 6. Peak hour traffic volumes at the intersection of Foote Avenue and A Road

Discussion and Recommendations:

The intersection of Foote Avenue and A Road has one-lane approaches in the northbound and southbound directions. The eastbound approach has an exclusive left-turn lane, a through lane, and a shared through/right-turn lane. The westbound approach has an exclusive left-turn lane, two through lanes, and an exclusive right-turn lane. The intersection has two-way STOP control posted on the A Road approaches.

Occasionally, northbound traffic turning right at the intersection uses the shoppette parking area to avoid traffic delays at the study intersection. Southbound A Road traffic, looking eastward, has limited sight distance due to the location of an installation destination sign. Motorists must extend beyond the stop line to see eastward.

The intersection of Foote Avenue and A Road experiences significant delay during the mid-day and evening peak hours.

- During the mid-day peak hour, queues of 10+ vehicles were observed on the northbound approach.
- Westbound left-turn lane traffic experienced queuing beyond capacity several times throughout the day. It should be noted that the westbound left-turn lane is to be extended as part of the Kolekole Connector Road Project that is currently under construction.
- Outbound (eastbound) traffic queues were observed extending from Kunia Road through the study intersection several times during the peak-hour periods.

The 3-year crash history includes 32 crashes. Eight crashes were category 1 crashes, 21 were category 3 crashes, and 3 were category 4 crashes (involving injuries). During data collection activities, several “near misses” were observed. The majority of “near misses” would have been right-angle collisions with some being rear-end collisions. Several times, vehicles making the southbound left-turn movement from A Road turned behind vehicles waiting to make a westbound left-turn movement from Foote Avenue (cut-behind movement).

Pedestrian activity at the intersection was minimal, except during the morning peak hour when PT activities take place. During all peak-hour periods, however, pedestrians had difficulty crossing the intersection. On one occasion, during the morning peak hour, a truck locked its brakes stopping for PT runners.

Based on the field observations as well as the analyses presented above the following improvements were identified to improve intersection safety:

- The intersection warrants signalization based on MUTCD Warrant 10, Peak Hour Delay:

From MUTCD 4C-10.2
Warrant 10, Peak Hour Delay

The peak hour delay warrant is intended for application where traffic conditions are such that for one hour of the day minor street traffic suffers undue delay in entering or crossing the major street. The peak hour delay warrant is satisfied when the conditions given below exist for one hour (any four consecutive 15-minute periods) of an average weekday.

The peak hour delay warrant is met when:

✓ *The total delay experienced by the traffic on one minor street approach (one direction only) controlled by a STOP sign equals or exceeds four vehicle-hours for a one-lane approach and five vehicle hours for a two-lane approach, and*

✓ *The volume on the same minor street approach (one direction only) equals or exceeds 100 vph for one moving lane of traffic or 150 vph for two moving lanes and*

✓ *The total entering volume serviced during the hour equals or exceeds 800 vph for intersections with four (or more) approaches or 650 vph for intersections with three approaches.*

The signalized intersection will operate at an overall LOS B during all peak hours. An actuated- traffic signal with two- phase operation will provide adequate gaps in A Road traffic to accommodate the left-turns; thereby reducing accident potential. Additionally, two-phase signal operation will eliminate the “cut-behind” movements created between southbound and westbound left-turn traffic movements.

The signal should be interconnected with the intersection of Foote Avenue and Kunia Road so that traffic backups along outbound Foote Avenue do not extend to A Road. The signal should be actuated so that Foote Avenue delay is limited. Also, the signal should accommodate pedestrians in accordance with the Americans with Disabilities Act. The estimated cost of the semi-actuated traffic signal, with pedestrian activation, is $70,000.

- Relocate the destination sign posted on the northeast quadrant of the intersection. The sign should be moved eastward to provide additional sight distance to southbound traffic. The estimated cost of this improvement is $250.

- Although not warranted at this time, an exclusive eastbound right-turn lane may be required to accommodate the additional traffic resulting from the Kolekole Connector Road Project. If constructed, the turning radii should be increased to accommodate truck traffic. During data collection several vehicles were observed “jumping” the curb.

WHEELER ARMY AIRFIELD

Crash histories show no current high accident locations.

FORT SHAFTER

Crash histories show no current high accident locations.

SAFETY AUDITS

As part of this study, safety audits were conducted on primary and secondary post roadways, at all three installations. The purpose of this task was to identify common safety deficiencies on the roadways. For the purpose of this study, the criteria set forth in the *AASHTO Roadside Design Guide* and the *MUTCD* was used as a guide in determining safety deficiencies.

It should be noted that this audit provides a general overview of safety conditions and does not detail all roadway deficiencies. The most common deficiencies noted during field observations, and ways to address them are listed below:

Fixed Objects - The *Roadside Design Guide* recommends clear zones (clear zone is the total roadside recovery area, starting at the edge of traveled way, safe for errant vehicles) for roadways dependent on speed, ADT and slope. Generally, clear zones range from 7 to 30 feet. All signs that are placed in the clear zone should be of a suitable breakaway or yielding design. Additionally, any fixed object within the roadway should be marked with an object marker sign.

Drainage – Drainage structures should be in conformance with clear zone guidelines as well. The following options can minimize the impacts to a vehicle colliding with a drainage structure:

From Roadside Design Guide (AASHTO):

For Cross-Drainage Structures
- ✓ *Use a traversable design*
- ✓ *Extend the structure so it is less likely to be hit*
- ✓ *Shield the structure*
- ✓ *Delineate the structure if the above alternatives are not appropriate*

For Parallel Drainage Features
- ✓ *Eliminate the structure*
- ✓ *Use a traversable design*
- ✓ *Move the structure laterally to a less vulnerable location*
- ✓ *Shield the structure*
- ✓ *Delineate the structure if the above alternatives are not appropriate*

Slopes – Steep slopes present within the clear zone should either be graded out to provide a recoverable area for motorists or, if this is not possible, the slope should be protected with guardrail.

Pavement Markings – It is important that all markings conform to MUTCD standards and that they are highly visible in order to convey to motorists, their intended use.

It should be noted that a common problem with markings at all three installations is the use of single broken yellow lines. This application is overused with most areas requiring double solid yellow markings. A single broken yellow line as defined in the MUTCD permits passing. Although this does not seem to be a problem since the majority of drivers know that they should not pass, the liability associated with allowing passing justifies double solid yellow markings. On low-volume roadways, the MUTCD does not even require a centerline marking for speeds below 35 mph.

From MUTCD 3B-1, Center Lines

A center line separates traffic traveling in opposite directions. It need not be at the geometrical center of the pavement. Centerlines provide important guidance to motorists and should be used on most paved roads. On roads where a continuous centerline is not used, short sections may be used to control the position of traffic at specific locations, such as around curves, over hills, and on approaches to intersections, railroad crossings, and bridges.

The center line markings on two-lane, two-way highways shall be either:
1. A normal, broken yellow line where passing is permitted (#2, sec. 3A-7), or

2. A double line consisting of a normal broken yellow line and a normal, solid yellow line where passing is permitted in one direction (#5, sec. 3A-7), or
3. A double line consisting of two normal solid yellow lines where passing is prohibited in both directions (#6, sec. 3A-7).

The center line on undivided highways where four or more lanes are always available, is usually a double solid yellow line.

On three-lane rural highways, two lanes should be designated for traffic in one direction and marked as illustrated in- figures 3-2a and 3-2b.

Center lines are recommended on paved highways under the following conditions:

1. In rural districts on two-lane pavements 16 feet or more in width with prevailing speeds of greater than 35 MPH.
2. In residence or business districts on all through highways, and on other highways where there are significant traffic volumes.
3. On all undivided pavements of four or more lanes.
4. At other locations where an engineering study indicates a need for them.

Pedestrian Accommodations – Some crosswalks and associated signing are not in conformance with *MUTCD* standards. Stop bars are not required at mid-block crosswalks. Additionally, there were some mid-block crosswalks without warning signs. Crosswalks should be signed in accordance with the MUTCD as shown in figure 7 and should be consolidated as much as possible to limit areas where pedestrians may cross the roadway. Corridors with several crossings can be signed at the start of the corridor to make motorists aware of pedestrian activity. In this case, it is useful to supplement the pedestrian crossing sign with a placard stating over what distance pedestrian activity takes place. It is important to be consistent in sign placement. If signing a group of crosswalks at the ends of a corridor, care should be taken so that either none of the intermediate crosswalks are signed or all of them are signed.

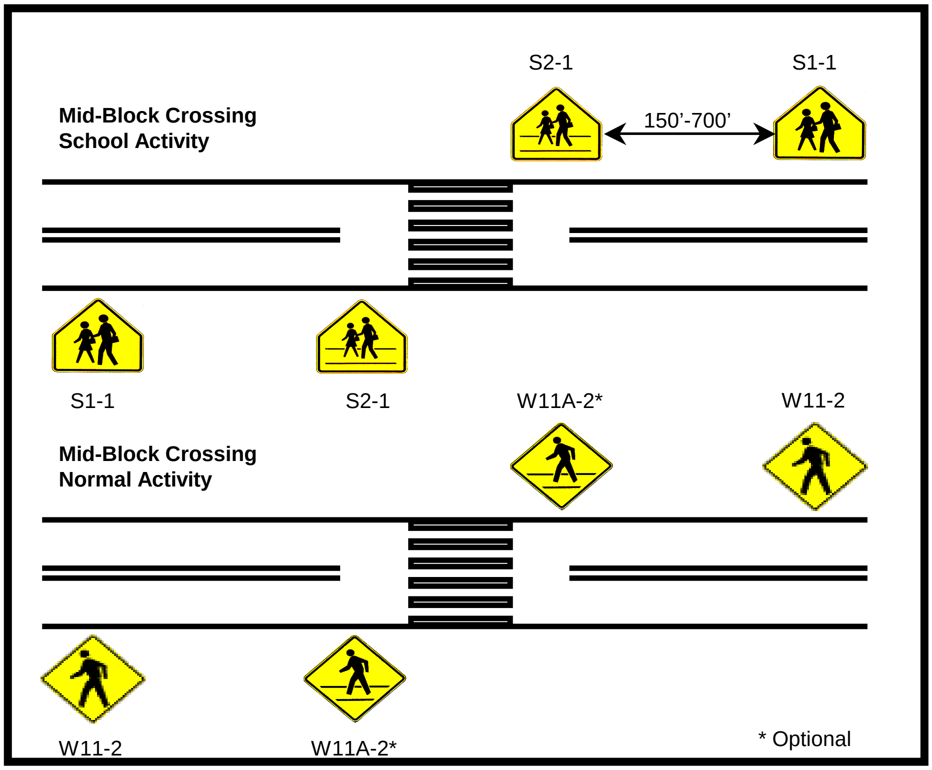

Figure 7. Proper mid-block crosswalk signage

Signs – Signs should exhibit retro-reflectivity and should be in conformance with *MUTCD* guidelines.

SCHOFIELD BARRACKS

Figure 8. Light pole on Cadet Sheridan Road near Williston Avenue (southward view)

Safety audits focused on the following primary roadways, as requested by DPW officials: Foote Avenue, Waianae Avenue, Kolekole Avenue, Lyman Road, and McCornack Road.

Fixed Objects

Numerous fixed objects were found to lie within the required clear zone.

- Figure 8 shows a light pole on Cadet Sheridan Road near Williston Avenue.
- Figure 9 shows a utility pole on Lyman Road close to the edge of travel way.
- Figure 10 shows an unprotected post mounted signal on Lyman Road at its intersection with Humphreys Road.

Figure 9. Utility pole within clear zone along Lyman Road near golf course (eastward view)

These objects are located within the 13-foot clear zone area that should be free of obstructions. Although relocation of these fixed objects is most desirable, the cost associated with this improvement may not be feasible. An alternate, lower-cost solution is to place concrete curbing at the edge of the roadways; thus reducing the required clear zone distance to 2 feet.

Figure 10. Post mounted signal pole at intersection of Lyman Road and Humphreys Road (eastward view)

Figure 11 shows a light pole that is centered within a 2-foot wide median on Trimble Road at its intersection with Hewitt Street. This condition was also noted at the intersection of Lyman Road with Carpenter Street. These light poles are an unnecessary obstruction that should be removed. Light poles should be placed at intersection corners, rather than within the median where they present a hazard to opposing traffic flows.

Guardrail used to protect steep slopes or other obstructions can sometimes become an obstruction in itself. In figure 12, a section of guardrail is shown on McCornack Road near Waianae Avenue. The guardrail is protecting a steep sideslope; however, its blunt end introduces a hazardous obstruction. An end treatment, in accordance with NCHRP 350, is required here. In addition, this guardrail lies close enough to a power pole that extending it slightly would

Figure 11. Light pole in median at the intersection of Trimble Road and Hewitt Street (westward view)

Figure 12. Blunt-end guardrail located along McCornack Road near Waianae Avenue (westward view)

also protect the pole. When damaged, guardrail can become more of a hazard than what it is protecting (fig 13). For this reason, damaged sections should be replaced as soon as possible.

ASSOCIATED TYPICAL COSTS

- $ Light Pole/Utility Pole Relocation - $5,000 - $10,000 EA
- $ Concrete Curb - $30 per LF
- $ Guardrail End Treatment - $1200 EA
- $ Guardrail - $30 per LF

Figure 13. Damaged guardrail at the intersection of Lyman Road and Duck Road (eastward view)

Figure 14. Drainage inlet within clear zone at intersection of Lyman Road and Mellichamp Road (westward view)

Drainage

Many drainage features on post are serious safety hazards because they present obstacles that may be impacted by motorists. Figure 14 shows a protruding headwall at the intersection of Lyman and Mellichamp Roads that should be replaced. Figure 15 shows the intersection of Lyman and Humphreys Roads where an unprotected headwall, located within the clear zone, protrudes in such a way that the roadside is non-traversable. This headwall should be replaced with a sufficiently sized inlet.

Figure 15. Drainage inlet delineated with posts and wire at intersection of Lyman Road and Humphreys Road (eastward view)

Figure 16. Drainage swale within clear zone along Lyman Road east of Mellichamp Road (eastward view)

Figure 17. Drainage swale and inlet within clear zone along McMahon Road near Carpenter Street (northeastward view)

Figure 18. Unstable guardrail along Lyman Road east of Mellichamp Road (eastward view)

Figures 16 (Lyman Road) and 17 (McMahon Road) show where drainage swales present a hazard by introducing a steep sideslope close to the edge of travelway. Where possible, closed drainage systems should be installed. If this is not practical, guardrail should be installed. Figure 18 illustrates where guardrail has been used to shield a steep sideslope to a drainage swale on Lyman Road. Due to erosion and the deterioration of guardrail posts, it is not likely that the guardrail would withstand a vehicle impact. This section of guardrail should be replaced.

On McMahon Road, a closed drainage system has been installed. However, the headwalls are not traversable and rigid steel posts, used to protect the concrete swale, introduce a fixed object hazard. The installation of several inlets would be preferable to the large protruding drainage structures. Figure 19 shows a large drainage structure along Lyman Road, near Flaggler Road, where a chain link fence is used to separate it from traffic. The nearby guardrail should be extended to properly protect traffic from this structure.

Figure 19. Drainage structure along Lyman Road near Flaggler Road (westward

Figure 20. Curb inlet at the intersection of Cadet Sheridan Road and Trimble Road (southward view)

Curb inlets, such as the one at the intersection of Cadet Sheridan and Trimble Roads (fig 20) should be redesigned. Curbing should be continuous around this turn with the inlet opening transition designed to reduce the potential of a motorist jumping the curb.

ASSOCIATED TYPICAL COSTS

- $ Inlet - $3,500 to $4,500 EA
- $ Concrete Headwall with Wingwalls - $2,500 EA
- $ 30" Diameter RCP - $85 per LF
- $ 30" Diameter CGSP - $45 per LF
- $ Guardrail - $30 per LF
- $ Concrete Curb - $30 per LF

Pavement Markings

Most pavement markings throughout the post are worn and faded. Figure 21 shows a westward view of a crosswalk at the intersection of Trimble Road and Cadet Sheridan Road that is barely visible.

ASSOCIATED TYPICAL COSTS

- $ Pavement Markings - $0.50 to $3.00 per LF

Figure 21. Faded crosswalk at intersection of Waianae Avenue and Kolekole Avenue

Pedestrian Accommodations

Crosswalks and the appropriate signing should be in accordance with the MUTCD as previously shown in figure 7.

On Trimble Road, a sidewalk paralleling the roadway is offset only three feet from the edge of travel way (fig 22). If a motorist were to even slightly drift off the road and hit a pedestrian, the results would likely be catastrophic. Where sidewalks are present along the roadway, curbing should be installed to reduce the chance of an errant vehicle encroaching on the sidewalk.

Figure 22. No curbing to protect sidewalk along Trimble Road near Hewitt Street (westward view)

ASSOCIATED TYPICAL COSTS
$ Concrete Curb - $30 per LF

Signs

A review of signing proved that the majority of on-post signing is adequate. However, several deficiencies were noted:

- Although multiple lane approaches to intersections are marked with pavement markings, it can often be difficult for motorists to determine which lane to use at an intersection. This can become more difficult in nighttime and wet conditions as well as when pavement markings become worn. To supplement pavement markings, lane use control signs should be installed on multiple lane approaches.
- Unrelated signing should not be installed on a single post. An example of that was found on Lyman Road (fig 23) where a regulatory and warning sign are both mounted on a single post.
- Any fixed object within the roadway should be marked with a Type I or Type III object marker At the intersection of Waianae Avenue and Glennan Street, a raised concrete traffic diverter is present within the roadway. This diverter should be marked with an object marker to make drivers more aware of the obstruction within the roadway.

Figure 23. Warning and regulatory signs mounted on a single post along Lyman Road (eastward view)

ASSOCIATED TYPICAL COSTS
$ Signing - $30 per SF

Parking

The portion of Lyman Road near Lyman Gate allows head-in parking immediately adjacent to the travel way (fig 24) and has no controlled access. This creates a conflict between vehicles maneuvering into and out of the parking spaces and through-traffic on Lyman Road. Head-in parking should be eliminated in this area. An alternative to removing the on-street parking is to install curbing. Curbing will control access to the lot and reduce the conflict with Lyman Road traffic.

Figure 24. Parking along Lyman Road near Lyman Gate (westward view)

ASSOCIATED TYPICAL COSTS
$ Concrete Curb - $30 per LF

WHEELER ARMY AIRFIELD

Safety audits focused on the following primary roadways at Wheeler Army Airfield: Wright Avenue, Santos Dumont Avenue, and Lauhala Road.

Fixed Objects

Generally, fixed objects lie outside the required clear zones. One exception is at the west end of Wright Avenue near the gatehouse. A concrete wall that divides opposing traffic flows (fig 25) presents a safety concern. It appears that the end of this wall has been damaged in the past. The gate relocation project that will align Wright Avenue with Lyman Gate on Schofield Barracks should address this concern.

Figure 25. Blunt end rock wall on Wright Avenue near Foote Avenue (westward view)

If the gate relocation is delayed, the concrete wall could be temporarily protected with an approved crash attenuator. Because installation of an attenuator may not be aesthetically pleasing, another alternative is to taper the end section down to eliminate the blunt end. Since speeds are low on Wright Avenue the risk of vehicles ramping up the tapered end would be minimal. If the end is tapered, it should be marked with a Type II or Type III object marker in accordance with section 3C-3 of the MUTCD.

ASSOCIATED TYPICAL COSTS

- **$** Concrete Barrier Tapered End Section - $500 EA
- **$** Crash Attenuator - $2000 EA
- **$** Signing - $30 per SF

Drainage

Drainage features on post appear to be in conformance with standards set forth in the Roadside Design Guide.

Pavement Markings

Most pavement markings throughout the post are worn and faded (fig 26). A regular maintenance schedule should be followed to ensure that worn markings are replaced. The area of Kahana Road, near Lehua Road, consists of new pavement markings which are in conformance with the MUTCD (fig 27). Kahana Road should be the example for other roadways on post in need of new pavement markings. Most roadway centerlines are marked with a single broken yellow line. To prohibit passing, these

Figure 26. Faded crosswalk markings on Santos Dumont Avenue (westward view)

Figure 27. Pavement markings at the intersection of Lehua Road and Kahana Road (northward view)

centerlines should be replaced with double solid yellow lines consistent with Kahana Road.

ASSOCIATED TYPICAL COSTS
$ Pavement Markings - $0.50 to $3.00 per LF

Pedestrian Accomodations

Crosswalks and the appropriate signing should be in accordance with the MUTCD as previously shown in figure 7. Stop bars in advance of the crosswalk on Wright Avenue (fig 28) are not required. School Advance signs (S1-1) should be installed in advance of crosswalks in front of the elementary school located on Old Kamehameha Highway and Leilehua Road. Groups of crosswalks on Santos Dumont and Wright Avenues should be signed with a single Advance Crossing sign (W11-2) in each direction.

Figure 28. Incorrect use of stop bar for crosswalk at the intersection of Wright Avenue and Warhawk Street (westward view)

ASSOCIATED TYPICAL COSTS
$ Signing - $30 per SF

Signs

A review of signing proved that the majority of signing on post is adequate. Several deficiencies were noted:

- The Kahana Road approach to Lehua Road is posted with an extremely faded YIELD sign and a sign warning “SLOW BUMP AHEAD” when no such bump exists (fig 29).
- Wright Avenue is divided by a wide grass median and is intersected by numerous one-way side streets. At these intersections ONE WAY (R6-1) and STOP control (R1-1) signing is not always present to clarify the direction of travel for motorists approaching from Wright Avenue. Figure 30 illustrates signing procedures for divided roadways.

Figure 29. Faded warning and regulatory signs on single post at the intersection of Lehua Road and Kahana Road (northward view)

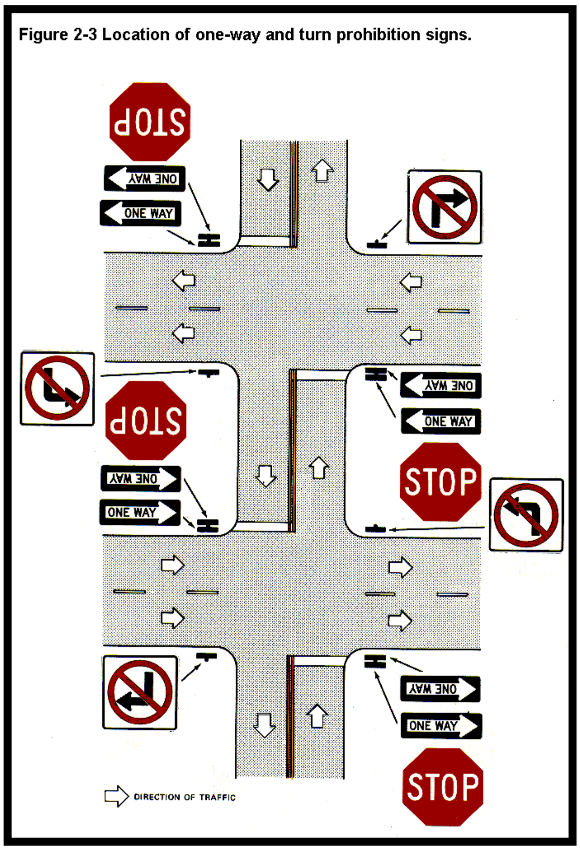

Figure 30. Signing procedures for divided roadways

<u>ASSOCIATED TYPICAL COSTS</u>

Signing - $30 per SF

FORT SHAFTER

DPW officials requested that safety audits focus on the following primary roadways on Fort Shafter: Funston Road, Wisser Road and Pierce Street.

Fixed Objects

Most post roadways provide an adequate clear zone, free of fixed objections. The majority of the primary corridors consist of curbed roadway sections that help prevent errant vehicles from exiting the roadways. Figure 31 shows an unprotected bridge parapet on Wisser Road. A similar situation was found on Funston Road near its intersection with 'I' Place. Constructing a tapered end section can eliminate the blunt end face of these parapets. Since speeds are low on these roadways the risk of vehicles ramping up the end section would be minimal. Additionally, an object marker should be placed at each parapet. Type III object marker signs, as shown at left, mark the object and direct traffic in the appropriate direction to reduce the potential for impact. The downward direction of the stripes indicates the direction of travel.

Figure 31. Wisser Road – Blunt end parapet (northward view)

ASSOCIATED TYPICAL COSTS

- $ Concrete Barrier Tapered End Section - $500 EA
- $ Signing - $30 per SF

Drainage

Drainage features along post roadways appear to be in conformance with standards set forth in the Roadside Design Guide.

Pavement Markings

Most pavement markings throughout post are in good condition; however, in some instances, their application is inconsistent. At the intersection of Funston and Wisser Roads (fig 32), the Wisser Road approach is marked with a single solid yellow centerline. The Funston Road approach consists of a double solid yellow centerline marking. As previously discussed under the safety audit definitions, double yellow markings should be used. At this same intersection, two different crosswalk markings

Figure 32. Intersection of Funston Road and Carter Drive (northward view)

Figure 33. Intersection of Funston Road and Carter Drive (northward

are used (fig 33). Each is acceptable but a consistent type of marking should be established throughout the installation.

ASSOCIATED TYPICAL COSTS	
$	Pavement Markings - $0.50 to $3.00 per LF

Pedestrian Accommodations

Crosswalks and the appropriate signing should be in accordance with the MUTCD as previously shown in figure 7. Groups of crosswalks on Funston Road (fig 34) should be signed with a single advance crosswalk sign (W11-2) in each direction.

ASSOCIATED TYPICAL COSTS	
$	Signing - $30 per SF

Figure 34. Funston Road east of Wisser Road (eastward view)

Figure 35. Speed limit sign on F Street (southward view)

Signs

A review of signing proved that the majority of signing on post is adequate. Several deficiencies were noted:

- Minimum speed limits are typically posted at 25 mph. Unrealistically low speeds (fig 35) are the greatest abuse of traffic control and should be corrected. Numerous speed studies have shown that drivers tend to operate at speeds that are reasonable to them. If speed limits are lower than necessary, many drivers will ignore them, thus creating conditions worse than those that would result from higher speed limits. Speed limits should be set after an engineering and traffic investigation has been made in accordance with established traffic engineering.
- Sign posts should normally consist of a single sign unless a second sign is supplements the meaning of the primary sign. On Wisser Road a bus stop sign is mounted on the same post as a STOP sign (fig 33). This bus stop sign could take away from the intended meaning of the STOP sign.

OPERATIONAL EVALUATIONS

Although this study is funded as a crash location enhancement study, it is important to note that traffic congestion and driver frustration often lead to unsafe conditions. Generally, when operational improvements are implemented, safety is improved as well. Therefore, several areas of operational concern were evaluated to determine if traffic operations could be improved.

SCHOFIELD BARRACKS

Macomb – Kolekole Connector

Figure 36. Intersection of Waianae Avenue and Kolekole Avenue (northward view)

Figure 37. Intersection of Waianae Avenue and Macomb Road (southward view)

The construction of the Kolekole Connector Road Project will improve traffic flow in the east-west directions. However, traffic using Macomb Gate will continue to encounter circuitous travel patterns to gain access to most parts of the installation. Based on field observations, a more direct north-south access is needed to relieve traffic congestion. At the present time, traffic entering the installation from Macomb Road must turn right and then turn left onto other roadways to gain access to other areas of the installation. A significant amount of traffic entering Macomb Gate utilizes Heard Avenue to travel southward. This pattern is partially responsible for operational deficiencies at the five-legged intersection of Trimble Road, Foote Avenue and Heard Avenue. This intersection is discussed in subsequent sections of this study.

To relieve traffic congestion, a north-south connector is recommended from Macomb Road to the Kolekole Connector Road (fig 38). The Macomb – Kolekole Connector should roughly follow the alignment as existing Kolekole Avenue from where it turns northward to Macomb Road.

The roadway realignment is complicated by buildings 361, 356, 355A, 321, 319, 317 and 315; however, it is doubtful that the demolition of these buildings would be required

KEY:

KOLEKOLE CONNECTOR

PROPOSED MACOMB-KOLEKOLE CONNECTOR

ROADWAY REMOVAL

FIGURE 38
PROPOSED MACOMB-KOLEKOLE CONNECTOR

Gannett Fleming

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for construction with the possible exception of building 361. Additionally, the realignment would require the removal of several trees along Macomb Road. Since Macomb Road is two lanes wide (one-lane in each direction), it is assumed that the connector should also be designed as a two-lane roadway (current width of Kolekole Avenue is 22 feet).

At the present time, there is an access roadway that connects the intersection of Macomb Road and Waianae Avenue to housing areas located along Millet, Suout, Charleston and Jecelin Streets, as well as General Loop. As part of the realignment, this access should be restricted since access is available at other locations.

Foote Avenue and Waianae Avenue Circulation Patterns

At the present time Foote Avenue and Waianae Avenue are one-way pairs that provide east-west access from Devol Street to Glennan Street. As an interim measure to alleviate congestion associated with the Kolekole Connector Road Project, parts of Waianae Avenue have been converted to two-way operation.

With the Kolekole Connector Road Project nearing completion, there is indecision as to what the future circulation patterns of Foote and Waianae Avenues should be. The two alternatives being considered are:

- **Alternative 1** - Two-way traffic operation on both Foote and Waianae Avenues, or
- **Alternative 2** - One-way traffic operation on both Foote and Waianae Avenues with a dedicated parking lane along each road.

This conversion to two-way operation is dependent on the ability of the roadway to accommodate two-way traffic based on existing geometrics.

The evaluation of a two-way street system should not be based on its merits alone, but in comparison to the operation of a one-way street system relative to several factors including operations, safety, circulation, parking, and loading zones.

Advantages and disadvantages of two-way operation versus one-way operation includes:

Conversion of Foote Avenue and Waianae Avenue to Two-way Operation	
Advantages	**Disadvantages**
Less confusing for visitors.	*Capacity at signalized intersections (if required) reduced 25 to 30%.*
Reduces overall travel distance.	*22 to 25% increase in accidents at signalized intersections.*
Easier access to facilities.	*Less room for parking.*
Improves emergency vehicle response times.	*Turning radii may be more restricted.*

Based on our observations, it is suggested that Alternative 1 be implemented. However, the installation staff should determine the final decision since they are more aware of user concerns.

Recommendations are based on field observations only. To make a proper engineering evaluation of the alternatives, a more detailed study which includes analyses of traffic volume data and travel patterns is required.

Intersection of Trimble Road, Foote Avenue and Heard Avenue

The intersection of Trimble Road, Foote Avenue and Heard Road is a five-legged intersection with STOP control posted on the Foote and Heard Avenue approaches. A DO NOT ENTER sign prohibits traffic from entering the south leg of the intersection. It is expected that the Kolekole Connector Road Project, as well as other proposals previously discussed, would necessitate operational changes at this intersection due to changes in traffic flow patterns.

MTMC Report TE 85-6a-54 suggested signalizing the intersection since traffic signal warrants were met. Signalization has not taken place due to a lack of funding. Based on the data available at the time of this study, it appears that signalization is still justified regardless of the exact configuration of the intersection.

If Foote and Waianae Avenues are converted to two-way operation, we recommend that the one-way direction of Heard Avenue north of the intersection be reversed to the northbound direction. This would alleviate some of the operational concerns at the intersection. Traffic currently using Heard Avenue to travel southbound would be able to use the Macomb – Kolekole Connector and bi-directional Foote Avenue to gain access. If Foote and Waianae Avenues remain a one-way pair, the current directional patterns should be maintained.

Other operational and safety concerns include the parking on the quadrant between Foote Avenue and Trimble Road. At the present time there is no access control at the parking lot that creates a safety hazard. Curbing should be installed such that access is managed properly.

Intersection of Waianae Avenue and McCornack Road

The intersection of Waianae Avenue and McCornack Road is a four-legged intersection with STOP control on all approaches. Field observations did not reveal any operational deficiencies. As with any four-way STOP controlled intersection, some delay is associated with driver confusion when vehicles arrive simultaneously.

If vehicles are not stopping at the intersection and crashes occur, approach rumble strips can be installed to make motorists aware of an impending STOP condition.

WHEELER ARMY AIRFIELD

Lauhala Road and Warhawk Field Road at Santos Dumont Avenue Gate

Lauhala Road and Warhawk Field Road intersect approximately 100 feet from the entrance gate on Santos Dumont Avenue. It is often difficult for drivers to turn left onto Santos Dumont Avenue from these side streets because of uncertainty in how long it will take to process vehicles at the gate. This processing time affects the size of gaps in the traffic stream on Santos Dumont Avenue.

The most desirable solution for improving access to Santos Dumont Avenue would be to increase the distance from the gate to the Lauhala Road / Warhawk Field Road intersection. The location of Lauhala Road, however, is constrained by the Airfield. Moving the gate towards the Kamehameha Highway is also not possible since it is already a short distance (less than 100 feet) from the roadway.

The recommended solution for the gate/intersection area is to widen the grass median on Santos Dumont Avenue. This would allow left turns from the side streets to proceed into the median without having to wait for a simultaneous gap in both traffic streams. Drivers could enter the median with the first acceptable gap they see to their left. Once within the median they could then focus on the gaps to their right. In addition to providing more opportunities for motorists to enter Santos Dumont Avenue, the sight distance beyond the gate will improve for drivers turning left out of Lauhala Road since they now would be looking towards the gate from the median.

Lehua Gate and Kamehameha Highway

During the morning peak period the Lehua Gate is opened to allow nearby housing residents access to Kamehameha Highway (SR 99), a four-lane divided state highway. The median for this roadway is grass except in front of the gate where the median is paved. The paved area is not intended to be crossed by traffic since it is graded as an asphalt swale for drainage along the median centerline. Motorists often turn left from the gate and cross this median. The typical movement consists first of crossing the southbound lanes and waiting in the median for a gap in the northbound traffic before entering the northbound lanes. Sight distance is not a problem in either direction. The safety concern with this movement is the narrow median width. When motorists wait in the median for a gap in northbound traffic, the tail end of their vehicle sometimes protrudes into the southbound travel lanes. If drivers angle their vehicle sufficiently this is not a problem but then it becomes more difficult to see approaching traffic over their shoulder.

A short-term, low-cost improvement would be to prohibit left turns at Lehua Gate by installing R3-2 “NO LEFT TURN” signs. Drivers may or may not obey this sign. The long-term desirable improvement would be to remove the asphalt median and plant grass to match the adjacent median section. Drivers would be forced to turn right and could then make a U-Turn at the signalized intersection with Waikalani Drive, 0.8 miles to the south.

FORT SHAFTER

Intersection of Funston Road, C Street and G Street

Figure 39. Intersection of Funston Road, C Street and G Street (northward view)

The intersection of Funston Road, C Street and G Street is controlled by STOP signs posted on the C and G Street approaches. Funston Road consists of one lane in the eastbound direction and three lanes (separate left, through, and right) in the westbound direction. On C and G Street a shared left-through and a separate right-turn lane are provided.

Based on field observations the following deficiencies were noted:

- The R1-1 (STOP) sign on the northbound approach cannot be seen by motorists due to vegetation growth (fig 39). Vegetation should be trimmed to provide proper sight distance.
- The pedestrian crosswalk on the westbound approach is difficult for motorists to see due to the vertical alignment of the roadway. Flashing pedestrian warning devices are installed on both the eastbound and westbound approaches. However, the pedestrian crossing sign is missing from the flashing warning device in the eastbound direction. The sign should be reinstalled.
- The left-turn lane in the westbound direction uses incorrect lane line colors (figs 40 and 41). Yellow lines are used to separate traffic travelling in opposite directions. White lines are used to separate traffic travelling in the same direction. As can be seen in figure 40, a double yellow lane line separates the left-turn and through lanes on the westbound approach to the intersection. This line should be a solid white line. The transition area can be marked with white skip guide lines or have no markings. Figure 41 illustrates a solid single yellow lane line used improperly to separate traffic flow in the same direction. This line should be a solid white line.

Plans have been developed that propose relocating the C Street approach (Palm Circle Entrance) to provide better geometrics. The proposal aligns the G and C approaches opposite one another and improves the visibility of pedestrian crosswalks. The plans have been reviewed and the following items were noted:

- The plans do not improve the sight distance restriction of northbound motorists looking eastward. Presently, there is approximately 200 feet of sight distance.

Figure 40. Approaching intersection of Funston Road, C Street and G Street (westward view)

Figure 41. At intersection of Funston Road, C Street and G Street (westward view)

- The plan introduces a two-lane section leaving the intersection in the westbound direction. The lanes are proposed to be separated by a 93-foot long solid white lane line. One lane is intended to be used as an acceleration lane for northbound traffic turning left and the other lane is for westbound through traffic. Although this makes geometric sense, the proposed pavement markings may give left-turn motorists a false sense of protection. Realistically, westbound vehicles will transition into the two lanes from the one lane approach through the intersection. Therefore, we suggest that the 93' solid white lane line be a broken white lane line (10-foot line, 30' skip).
- The signage and striping plan shows a through-right pavement marking arrow legend on the one-lane southbound approach. Based on this treatment, left-turns from the southbound approach are restricted. However, no R3-2 ("NO LEFT TURN") signs are proposed to be installed. If left-turns are restricted on the southbound approach, R3-2 signs should be installed on the far left-hand corner and near right-hand corner of the southbound approach. If left-turns are not restricted, the pavement marking arrow legend should be eliminated.
- The signage and striping plan shows the use of the "ONLY" pavement marking on the northbound approach only. If word markings are installed at the intersection, they should be installed on all applicable approaches.

Intersection of Funston Road and Bonney Loop

Bonney Loop intersects Funston Road at approximately a 45-degree angle. The eastbound approach is on an uphill grade. These two factors lead to intersection conflicts for vehicles making an eastbound right-turn movement. Based on field observations, it appears that most vehicles smaller than single unit trucks can make the right-turn maneuver without difficulty. Larger trucks and buses have difficulty making the right-turn movement and infringe on northbound lanes. A low cost alternative may be to restrict trucks from making the right-turn movement.

The sidewalk located in the southwest quadrant of the intersection includes steps (fig 42). This treatment is not compliant with ADA requirements and should be replaced by a ramp.

Figure 42. Intersection of Funston Road and Bonney Loop (northward view)

Figure 43. Intersection of Wisser Road, Pierce Street and Macomb Road (southward view)

Intersection of Wisser Road, Pierce Street and Macomb Road

The intersection of Wisser Road, Pierce Street and Macomb Road is a confusing intersection due to its many legs and crossings (fig 43).

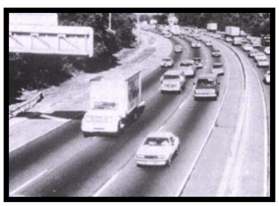
One solution is to eliminate the northeast quadrant (short connector road at left in fig 43) of this intersection, thereby reducing the number of conflict points. The elimination of this connection would create a standard four-way STOP controlled intersection that is less confusing than the present configuration. This modification may require that the radii on the northeast quadrant be increased to accommodate larger vehicles. The Macomb Road approach can be aligned with Pierce Street such that it becomes a T-intersection.

Intersection of Funston Road, Wisser Road and Carter Drive

The type of configuration discussed in the previous section also exists here. Eliminating the connector road from Carter Drive to Funston Road in the southwest quadrant of this intersection is recommended. This connector road currently intersects Funston Road opposite Bonney Loop. Eliminating the connector road would also improve traffic operations at the Bonney Loop intersection since traffic turning left from Bonney Loop would not have to contend with opposing traffic.

Appendix A
Level of Service Definitions

LEVELS OF SERVICE

LOS	ROADWAY SECTIONS		SIGNALIZED INTERSECTIONS	
A		Free-flow operations. Vehicles unimpeded within traffic stream. Average spacing between vehicles about 400 ft. (22 car lengths) Maximum density of 12 PC/MI/LN.		Very low delay (less than 5.0 sec per vehicle). Most vehicles arrive during the green phase.
B		Free-flow conditions. Average spacing between vehicles about 250 ft. (13-car lengths) Maximum density of 20 PC/MI/LN. Ability to maneuver is only slightly restricted.		Delay in range of 5.1 to 15.0 sec per vehicle.
C		Stable operations. Average travel speeds still over 75% of free flow speed Average spacing between vehicles about 175 ft. (9 car lengths) Maximum density of 30 PC/MI/LN.		Delay in range of 15.1 to 25.0 sec per vehicle. Longer cycle lengths. Cycle failures may begin to appear. Number of vehicles stopping is significant.
D		Borders on unstable flow. Average travel speed 85% or more of free-flow speed. Freedom to maneuver severely limited. Average spacing between vehicles about 125ft. (6 car lengths) Maximum density of 42 PC/MI/LN.		Delay in range of 25.2 to 40.0 sec per vehicle. Congestion more noticeable. Many vehicles stop Cycle failures noticeable.
E		Operations at capacity. Extremely unstable. No unable gaps in traffic stream. Vehicles spaced about 80 ft (4 car-lengths) at relatively uniform headways. .		Delay in range of 40.1 to 60.0 sec per vehicle. Limit of acceptable delay. Long cycle lengths. Cycle failures frequent.
F		Forced or breakdown flow. Complete congestion.		Delay in excess of 60.0 sec per vehicle. Delay unacceptable to most drivers. Many cycle failures.

Appendix B
Levels of Service
By Movement

Intersection	Time Period		
	Morning	**Midday**	**Evening**
Foote Avenue and A Road – Existing Conditions (two-way STOP controlled)			
SB Left/Through/Right	C	D	E
NB Left/Through/Right	C	F	E
WB Left	B	B	B
EB Left	A	A	A
Foote Avenue and A Road – Proposed Conditions (traffic signal controlled)			
SB Left/Through/Right	A	A	A
NB Left/Through/Right	A	A	A
WB Left	B	C	C
WB Through	B	B	B
WB Right	B	B	B
EB Left	B	A	B
EB Through/Right	B	B	B
Overall	**B**	**B**	**B**

Appendix C Benefit-Cost Analysis

FORT IRWIN ROAD

Improvement	Expected Result	Initial Improvement Cost	Annualized Improvement Cost (1)	Improvement Life (Years)	Reduction Factor	Annual Accident Damage Addressed PROPERTY	INJURY	FATAL	Annual Monetary Benefit (1)	B/C Ratio
FOOTE AVENUE AND 'A' ROAD										
Install actuated traffic signal with pedestrian activation (2	Reduction in angle accidents, improved safety for crossing pedestrians	$70,000	$6,296	15	0.200	4.8	0.5	0	$13,620	2.16
Relocate destination sign on northeast quadrant (3)	Improve sight distance for southbound vehicles	$250	$18	20	0.500	1	0	0	$6,000	326.17

NOTE:
1. ANNUAL RATE OF INFLATION ASSUMED TO BE 4 PERCENT
2. DETAILED ACCIDENT DATA WAS NOT AVAILABLE. IT WAS ASSUMED THAT 50% OF ALL ACCIDENTS WOULD BE ADDRESSABLE BY A SIGNAL.
3. ONE PROPERTY DAMAGE ACCIDENT PER YEAR WAS ASSUMED TO BE CAUSED BY SIGN OBSTRUCTION.